THE GREEN SUN OF THE KRAKATOA ERUPTION.

Referring to page 163 of the MONTHLY WEATHER REVIEW for April, 1906, wherein, speaking of the color of dust haze, the Editor states that the whiteness of the diatom dust in the harmattan is a diffraction phenomenon, produced by the action of minute irregular objects upon a beam of light, Prof. R. W. Wood remarks:

> The green sun observed thru the haze attending the Krakatoa eruption could never have been produced by diffraction, and I doubt if it is a thin plate phenomenon due to the passage of light thru the centers of small globules, as in the experiments of Prof. Carl Barus. I favor the explanation given by Prof. C. Michie Smith, in the Proceedings of the Royal Society of Edinburgh, Vol. XIII, page 116, where he says: "I have discovered that the green sun spectrum can be exactly represented by combining the spectrum of the sun seen thru a fairly thick mist and the spectrum of a moist atmosphere showing the rain bands strongly ".
>
> If plenty of water vapor will, by absorption, cut off enough of the red end, that is all that is necessary, as the rest of the spectrum would have a greenish appearance, which would be more marked if the violet and the blue were removed by haze. I should expect that sufficient water vapor would greatly cut down the red end, tho I am quite sure that no one has ever worked with a long enough column of dense water vapor to observe any coloring. Janssen worked with a column over a hundred feet long (a tube filled with steam at seven atmospheres), and observed a strong absorption of blue and violet. He attributed this to the vapor, but it is more probable that it was due to a haze of condensed steam. Why not work with an optical path of much greater length ? A pressure of one hundred atmospheres could probably be used without trouble. But this experiment could not be done properly without very carefully constructed apparatus, the cost of which would be considerable.

INTERNATIONAL WEATHER CABLEGRAMS.

In accordance with arrangements between the Chief of the Weather Bureau and the director of the Central Physical Observatory observations from several Russian stations will be reported daily by telegraph and cable from St. Petersburg to the Central Office of the Weather Bureau at Washington. To begin with the 7 a. m., local time, observations at Irkutsk, Tomsk, and Ekaterinburg will be sent, the barometric readings and the direction and force of the wind only being reported by the use of the cipher weather code that will convey in one word for each station the information desired. The Chief of Bureau appreciates very highly the cooperation in the work of international meteorology of the Central Physical Observatory, whose general director, M. Rykachev, has done so much to stimulate studies into the general dynamics of the atmosphere.

It may not be generally known that for several years the Central Office at Washington has been receiving and publishing daily cable reports from three stations in Ireland, two in Scotland, one each in England, Germany, France, Portugal, the Azores, and Bermuda, and about twelve in the West Indies, and that since the establishment of cable communication with the Hawaiian Islands daily weather reports have been received from Honolulu. It will be of interest to know that preliminary steps for the inauguration of a similar service of reports from points in Alaska have been taken, and that with the completion and operation of the Iceland cable a daily service from that quarter is contemplated.

The extension of the area of daily weather reports is being made for the purpose of determining the relation and interrelation of barometric conditions over the oceans and the continents, and the discovery of this relation, that will undoubtedly be made by a study of the reports, will open the way for greater achievements in the accuracy and the period of weather forecasting.—*E. B. G.*

Mr. H. M. Watts, of the Philadelphia Press, in a recent communication to the Philadelphia Academy of Natural Sciences, pointed out that a new epoch in meteorological research is about to dawn, in that the Weather Bureau is soon to receive daily telegraph and cable reports from new regions of the Northern Hemisphere, which are meteorologically very important. In explaining the significance of this Mr. Watts went into a careful survey of the great basic causes of variations in weather and climate. The variations in solar radiation appear to have some effect on the great permanent anticyclones, whose slight changes of intensity and location so greatly affect the paths of storms.

Furthermore, Mr. Watts called attention to the fact that at Mount Weather the Bureau will prosecute studies of the variations in all the solar functions, in connection with researches in the elements of the earth's atmospheric envelope.

THE ZODIACAL LIGHT.[1]

By Prof. ARTHUR SEARLE. Dated Harvard College Observatory, Cambridge, Mass., October 1, 1906.

The prolonged and careful series of observations of the zodiacal light made by Mr. Maxwell Hall, which appeared in the MONTHLY WEATHER REVIEW for March, 1906, Vol. XXXIV, p. 126, forms a welcome addition to our previous information. Its value is increased by the circumstance that the observer was apparently free from any prejudice which might have resulted from a too extensive acquaintance with the work of other inquirers into the same subject. Observations of the zodiacal light are certainly best made without much knowledge of what has been the experience of others. When deductions are to be made from such observations, however, the student should know as much as possible about the existing material for discussion.

Unfortunately, it has hitherto been customary for each observer to draw his own conclusions almost exclusively from his own observations, and the consequence has been the production of a considerable mass of speculation tending rather to encumber than to assist the progress of definite research. In the present article all reference to theories of the zodiacal light will be avoided. Its purposes are—First, to bring together some facts which seem to be of interest, in view of Mr. Hall's work, and of the editorial comments which follow it; Second, to present suggestions which may be of use to future observers.

The question whether the altitude of the observer's station affects the visibility of the zodiacal light is raised in the editorial comments just mentioned, and seems capable of a fairly conclusive answer. The altitude of Mr. Hall's own station was only 1800 feet; but he quotes observations made by Professor Newcomb in Switzerland at the altitude of 8000 feet. Some additional records of observations made at considerable altitudes are given below.

1. Alexander von Humboldt: "Cosmos", English translation by Otté, published in Bohn's Scientific Library, London, 1849. Volume I of this work, at page 126, contains this passage relating to the zodiacal light:

> I have seen it shine with an intensity of light equal to the milky way in Sagittarius, and that not only in the rare and dry atmosphere of the summits of the Andes, at an elevation of from thirteen to fifteen thousand feet, but even on the boundless grassy plains, the Llanos of Venezuela, and on the seashore, beneath the ever clear sky of Cumana.

Humboldt seems, by this statement, to have presumed that the zodiacal light would be best seen at great elevations, and actually to have found that it was seen at least as well from the tops of mountains as at lower levels. His South American journeys were made in the years 1799–1804.

2. C. Piazzi Smyth: "Report on the Teneriffe Astronomical Experiment of 1856, London and Edinburgh, 1858". During the months of July, August, and September, 1856, Smyth made

[1] As this article by Prof. Arthur Searle definitely settles the old question as to whether the zodiacal light and gegenschein are atmospheric or celestial phenomena, we shall hereafter commend the publication of such material to the astronomical journals, and reserve the columns of the MONTHLY WEATHER REVIEW for meteorology proper.—EDITOR.

observations of various kinds from stations on the peak of Teneriffe. The altitude of one station, Guajara, was 8903 feet; that of another, Alta Vista, was 10,702 feet (p. 476). At both these stations the zodiacal light was well seen (p. 490); at Alta Vista (p. 491) it was slightly visible even at 1 a. m.

3. G. Jones: "Observations on the Zodiacal Light at Quito, Ecuador, with deductions".[2] Jones observed from the hill Ychimbia, near Quito; the altitude of the town itself is given as 9520 feet in the Encyclopedia Britannica. The observations were made in the eight months following August, 1856, beginning about the time when those of Smyth ended. Jones found at this station that everything distinctive in any celestial phenomenon, undoubtedly meaning by this expression to include the zodiacal light, was brought out with a distinctiveness he had never before witnessed (p. 375). He was able to trace the light quite across the sky in the form of a zodiacal band, which he saw afterwards even at lower levels. A plate accompanies his article, from which it appears that the ascending node of the central line of this band was at about 60° of celestial longitude.

4. A. E. Douglass and others: "Positions of Gegenschein."[3] The observations here given relate only to gegenschein; but the zodiacal light in general is known to be remarkably conspicuous at Arequipa, where these determinations were made. The altitude of the station is 8043 feet.[4] The dates of the observations are in the years 1891 and 1892.

5. E. Marchand: "Observations de la lumière zodiacale, faites à l'observatoire du Pic du Midi.[5] The altitude of the barometer of the Pic du Midi Observatory is 2859 meters (about 9380 feet) according to Rotch.[6] Marchand's observations were made in the years 1892–1895. Like Jones, he was able to trace a zodiacal band across the sky. He makes the longitude of the ascending node 70°, a result in pretty good agreement with that of Jones.

6. Mr. Innes, of the Government Observatory, Johannesburg, South Africa, has recently stated in a letter kindly forwarded to me by Professor Abbe, to whom it was addrest, that "at Johannesburg, 5925 feet altitude, the zodiacal light is always distinctly visible on clear, moonless nights. The gegenschein is also to be seen, unless its position should happen to be too near the milky way or near a bright planet, but it is never conspicuous".

The evidence above quoted seems to place it beyond doubt that a great altitude is at least no hindrance to observations of the zodiacal light. Of course, at any particular station, local circumstances may tend to produce slight condensations of vapor which may obscure faint celestial phenomena. But however clear the sky may be at a given station, we can not expect that an observer not personally interested in the subject, but merely looking at the zodiac as a matter of routine, should notice anything there to be recorded. When a pictorial representation is made of the zodiacal light, as in the plate accompanying Mr. Hall's article, it necessarily appears as a conspicuous object, with well-defined boundaries. In fact, however, it is always very indefinite, and altho it may be easily perceived by any one who takes the trouble to compare carefully the relative degrees of brightness shown by different parts of the sky, it seldom attracts the attention of the casual spectator. The first requisites, then, for an observer of the zodiacal light, are interest in the subject, patience, and perseverance.

The indefinite character of the light to be observed not only prevents its customary recognition, but makes it difficult to obtain any satisfactory comparison between the various reports of observers, all of whom may be equally careful and competent. It is highly desirable that future observers should agree upon some definite system of procedure which may make their results readily capable of combination. It may be worth while, therefore, to repeat here a suggestion made on former occasions (for example, in Appendix B to the "Laboratory Manual in Astronomy" by Mary E. Byrd, Boston, 1899) that, instead of drawing boundaries incapable of definition, observers should always draw contour lines, that is, lines along each of which the light is thought to have everywhere the same degree of brightness. This degree should be defined, by comparison at the time of observation, as that equal to the brightness of some small stated portion of the sky, not affected by the zodiacal light. This, of course, will usually be situated in or near the milky way.

Contour lines of the kind just proposed are most conveniently drawn by covering a map of the stars with a piece of tracing paper, and marking upon it the places of a sufficient number of stars to ensure the replacing of the paper in the same position at any future time. A contour line drawn upon the paper can thus be definitely located by the observer when he has time for the study of his observations. It is usually impracticable to draw small parts of such a line by successive observations, because the eye needs time, after any record has been made, to recover its sensitiveness, and meanwhile the diurnal motion of the stars, not to mention other causes, will change the conditions of the observation. As much of the line as can be decided upon must be drawn at once, with a record of the time of the observation, and any further work must be treated not as a continuation of that observation, but as one entirely independent of it.

At present we know scarcely anything of the degree to which observations of the zodiacal light are affected by the personal peculiarities of observers. Accordingly, it is much to be desired that more than one observer, at any given place and time, should carry on the work. The observers should agree upon some one point of a proposed contour line, and then proceed to make their simultaneous observations entirely independent in all other respects. It has been found by trials of this kind that contour lines thus drawn by two observers, altho necessarily coincident at the selected point, deviate from each other in places as much as five degrees. But, as has been remarked in the Appendix above mentioned, observers should not be discouraged by discrepancies of this kind, for until it is known how much difference may be expected between results obtained at the same place and time, it is evident that we shall have little satisfaction in comparing observations made at different stations and in different years.

The zodiacal light has sometimes been regarded as subject to comparatively rapid changes in brightness, occurring within a few minutes of time. Even when these changes appear to be verified by simultaneous comparisons with portions of the milky way, we can not be certain that they are real, unless two or more persons, observing wholly independently, should report them as occurring at the same time. So far as is known, this experiment has never been tried.

A possible source of error in observations of the zodiacal light in general, and of gegenschein in particular, is the presence in portions of the zodiac of faint bands of permanent light, due presumably to aggregations of small stars, and in that case to be regarded as faint branches of the milky way. Every observer intending to make useful observations of the zodiacal light should study the zodiac, and also the sky for a considerable distance on each side of it, at times when little or no zodiacal light is visible there, in order to make sure that in his later observations he is not confounding permanent with transient phenomena.

[2] American Journal of Science and Arts. Second Series, Vol. XXIV, pp. 374–385, November, 1857.

[3] Annals of Harvard College Observatory, Vol. XXXIII, p. 16.

[4] Annals, etc., Vol. XLVIII, p. 273.

[5] Comptes Rendus des Séances de l'Académie des Sciences. Tome 121, p. 1134. Paris, 1895.

[6] Mountain Meteorological Stations in Europe, p. 31. Ann Arbor, 1886.

It can scarcely be necessary to add that transient phenomena of other kinds, such as bands of auroral light at periods when auroras are frequent and intense, sometimes appear in the zodiac, and are mistaken for zodiacal light by inexperienced observers.

THE DIRECTION OF LOCAL WINDS AS AFFECTED BY CONTIGUOUS AREAS OF LAND AND WATER.

By T. H. DAVIS. Dated West Haven, Conn., July 21, 1906.

Thru my previous researches on local surface wind direction I have been led to believe that, so far as stations near large water areas are concerned, a large percentage of observed directions is due to the direct influence of contiguous land and water. For this reason I have continued my research in this line, selecting such stations as seem to be open to direct sea or lake winds. My computations have been somewhat voluminous, but I have endeavored to condense them so that the results can be studied without extensive explanatory matter.

For each station I have taken those winds which blow from the cardinal points, the paths of which have free ingress to the land, and the principle upon which I have based the study of the data is that of land and sea breezes. These appear to me to be much more extensive and to exert greater influence on local directions than is generally supposed or admitted. I strongly believe that winds of this character should receive greater consideration than hitherto, as valuable factors in the determination of local weather.

I have found, during the comparatively short time in which I have obtained continuous tracings of directions from a vane well exposed near the coast, what I believe to be indisputable proof of wind direction altogether independent of that which precedes, accompanies, or follows the passage of great areas of high or low pressure to the north or to the south of this point. It may be argued that all local winds are entirely the result of highs and lows, and that such as I have observed are simply averages of the effects of these areas. On the other hand I am led strongly to believe that a large percentage of winds over stations near large water areas is mainly, if not entirely, due to land and water contiguity. Careful study of weather maps will show how very frequently, over the Great Lakes and along the coasts, the winds of highs and lows are deflected.

The records of winds by only eight cardinal points do not constitute entirely satisfactory data for research. I believe that the scale of sixteen points should be used; this I did in former years when observing for the British Meteorological Office and am doing now at my own station. The results given in this paper are, however, from eight point observations, as recorded in the MONTHLY WEATHER REVIEW for the several years under consideration. Some of these in the earlier years seem to be not quite so correct as could be wished, particularly as to the large number of calms recorded for some of the stations. In my computations I have eliminated all these calms by adding them, proportionately, to those winds showing the greatest frequency.

In order that the results obtained should be as comprehensive as possible the following exposed stations were selected as representating the Pacific and Atlantic coasts, the Gulf of Mexico, and the Great Lakes:

San Francisco, Cal	Pacific coast.
San Diego, Cal	
Galveston, Tex	Gulf of Mexico.
Savannah, Ga	Atlantic coast.
New York, N. Y	
New Haven, Conn	
Boston, Mass	
Eastport, Me	
Marquette, Mich	Great Lakes.
Chicago, Ill	
Cleveland, Ohio	
Toronto, Ont	

I should much have liked to include several other stations, but not possessing the necessary information was unable to do so.

The results subsequently shown were obtained by tabulating from the records in the monthly reports as published by the Weather Bureau, the actual number of hours the wind blew from those points over the water areas, from which it had an unobstructed path to the land. This was done for each point, each month for twelve successive years, 1891–1902. The total of each column was divided by twelve to obtain an average number of hours for each point in each month and from this their percentages were determined to the first decimal point.

For example:

San Francisco, January, hours.

Year.	W.	SW.	W.+SW.
1891	94	78	172
1892	133	75	208
1893	117	43	160
1894	79	184	263
1895	32	129	161
1896	56	99	155
1897	46	12	58
1898	77	33	110
1899	97	59	156
1900	44	24	68
1901	126	33	159
1902	97	19	116
Total	998	788	1,786
Average	83	66	149
Percentage	11.2	8.9	20.1

This table will serve as a general explanation of the method adopted for computation of results for each station selected.

In this paper I have restricted my observations to the winds flowing from seaward points to the land, as these seem to be more marked than those from land to sea, by reason, no doubt, of the more marked effect of the intensity of insolation. The monthly and annual variation of this intensity very probably accounts for the variability in the frequency of true sea winds in the earlier and later months of the several years under consideration, for while the accompanying tables of average percentage indicate considerable regularity in the change of prevalence of the sea winds from January to July and August, and from these months to December, yet each individual month during the 12-year period, in most cases, shows considerable variation in frequency. But the total number of sea winds for each year of the same period does not show any very great variation, at any rate not more than what may be expected from the effect of average insolation for each year.

In two or three cases I endeavored to make comparison between the frequency of sea wind and the mean annual temperatures during the whole period, but was unable to discover any reliable relation. This really may be expected, because, after all, the conditions of insolation are such that it does not necessarily follow that intermittent hot periods should produce those atmospheric effects which are induced by superheated land areas.

The determination of sea and land winds is complex because of the difficulty of quantitatively separating actual sea winds from the total winds composed of these and of those which are the effects of high and low areas. This I believe to be too abstruse at present for any attempt at separation to be made, but I do believe that the result of my research indicates pretty clearly that the percentages do actually prove a large frequency of true sea winds blowing independently of any other atmospheric condition, because of the regular progression of the figures from winter to summer and the same regular recession from summer to winter. If it were possible to eliminate the influences of high and low areas I firmly believe that percentages would be found showing pretty perfect progression and recession without any pronounced variability.